REMARKS

Favorable reconsideration of this application, as presently amended and in light of the following discussion, is respectfully requested.

Claims 1-3, 9-12, 15, and 23 are active in this application. By this Amendment, the Applicants amend Claims 1, 9-12, 15, and 23, and cancel Claims 5, 6, 13, 14, 16-22, 24, and 25.

Claims 1-3 and 9-25 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 1 was rejected as having contradictory requirements. Claim 1 has been amended to remove the phrase "the deposit caused to degenerate by irradiation by said second laser beam...." Accordingly, Claim 1 no longer contains contradictory language. Claims 10 and 13-25 were rejected as reciting structural features that differed from the material claimed in the preamble. Claims 13, 14, 16-22, 24, and 25 have been canceled, thereby rendering the rejection of these claims moot. Additionally, Claims 10, 15, and 23 have been amended to recite methods for marking material that depend from Claim 1. The claims have been amended to remove any inconsistent references to the marking material and the product of the chemical reaction. Regarding the use of the phrases "QR Code," "Data Code" and "Veri Code," the Applicants submit that these art terms of art that are known to those of skill in the bar code art, and the Applicants submit that these phrases are not trademarks or trade names. The Applicants have attached an Appendix with an article entitled "An Introduction to Bar Coding," which was found on the internet at the following address:

http://www.itsc.org.sg/synthesis/2001/itsc-synthesis2001-jinsoon-bar-coding.pdf. The article describes each of these phrases. While this article may or may not provide a complete description of the common usage of these terms, it does provide support for the assertion that these phrases are of common usage and do not appear to be trademarks or trade names.

Based upon the above discussion, the Applicants request the withdrawal of the indefiniteness rejections.

Claims 10, 16, and 23-25 were rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the invention. On page 4 of the Official Action, a non-enablement rejection is set forth which appears to suggest that the limitation regard a thin film thickness of 10 μm or less is not enabled. The Applicants note that the specification clearly provides disclosure and support for this limitation in original Claim 10. Regarding whether this limitation is enabled, the Applicants submit that the standard for determining whether the specification meets the enablement requirement is whether one skilled in the art could make or use the invention from the disclosures in the application without undue or unreasonable experimentation. (See MPEP 2164.01.) In fact, the Federal Circuit has stated that a patent need not teach, and preferably omits, what is well known in the art. (See *In re Buchner*, 929 F.2d 660, 661, 18 USPQ2d 1331, 1332 (Fed. Cir. 1991) and MPEP 2164.01.) The test of enablement is not whether any experimentation is necessary, but whether, if experimentation is necessary, is it undue. (See *In re Angstadt*, 537 F.2d 498, 504, 190 USPQ 214, 219 (CCPA 1976) and

MPEP 2164.01.) As indicated in the Official Action, the specification describes an embodiment on page 10 that includes a thickness of 2 μm. Clearly one of skill in the art could have produced a thickness greater than 2 μm without undue or unreasonable experimentation based upon the disclosure of the present application. The Applicants are not required to describe an infinite number of embodiments for each thickness within the range recited in the claims, as such a requirement would be unduly burdensome.

With the above standards of enablement in mind, the Applicants submit that the above enablement rejection should be withdrawn.

The disclosure is objected to for minor informalities discussed on pages 4-5 of the Official Action. Figures 4(a), 4(a)(1), and 4(b), and pages 23-26 of the specification have been amended to distinguish the reference numeral 1 used in Figure 1(a) from a new reference numeral 1(b) used in Figures 4(a), 4(a)(1), and 4(b), which depict alternative embodiments of the present invention. The reference numerals used on lines 4, and 7-9 of page 26 with regard to alternative embodiments have been removed in order to prevent confusion. The Official Action notes that the spacing of the units in the specification may not print accurately, however, the Applicants submit that the text appears correct in its original form. Additionally, the Applicants respectfully submit that one of ordinary skill in the art would readily understand the units regardless of whether or not a space is provided between the letters in the units. Similarly, the Applicants submit that the units expressed on page 46 are correct and will be readily understood by one of skill in the art. The Applicants have amended the specification to correct the spelling issues raised regarding pages 29, 30, 32, and

48. Accordingly, the Applicants respectfully request the withdrawal of the objections to the disclosure.

Claims 1-3 and 9-25 were rejected under 35 U.S.C. 112, first paragraph. The Applicants traverse this rejection, however, in order to expedite prosecution Claim 1 has been amended to remove the language objected to in the Official Action. Accordingly, the Applicants request the withdrawal of the 35 U.S.C. 112, first paragraph rejection.

In the outstanding Office Action, Claims 9-25 were rejected under 35 U.S.C. §103(a) for obviousness over Cook (U.S. Patent No. 4,895,735) in view of Tatah (U.S. Patent No. 5,935,462) or Addiego et al. (U.S. Patent No. 5,164,565); Claims 9 and 10 were rejected under 35 U.S.C. §102(b) for anticipation by Hase et al. (U.S. Patent No. 5,281,575); and Claims 5 and 6 were rejected under 35 U.S.C. §103(a) for obviousness over Hase et al. in view of Cook. It is unclear from the Official Action whether a rejection is outstanding regarding Claims 1-3, since paragraph 10 on page 12 does not positively reject Claims 1-3.

The rejections of Claims 5, 6, 13, 14, 16-22, 24, and 25 have been rendered moot by the cancellations thereof. Furthermore, Claims 10, 15, and 23 have been amended to recite a method for marking material that depend either directly or indirectly upon Claim 1. Accordingly, the Applicants submit that the obviousness rejection of Claims 10, 13-25 based upon the Cook reference in view of either the Tatah or the Addiego et al. reference and the anticipation rejection of Claim 10 in view of the Hase et al. reference have been rendered moot.

Regarding the obviousness rejection of Claims 9, 11, and 12 based upon the Cook reference in view of the '462 Tatah reference or the Addiego et al. reference. The Official

Action admits on page 9 that the Cook reference does not disclose the specific steels recited, for example, in Claims 11 and 12. The Applicants submit that since the cited references do not disclose the method for marking materials expressly recited in Claim 1 (see discussion set forth below for reasons why Claim 1 is not disclosed in the references), it is unclear whether the particular alloy materials described in the Cook reference could be used in the method recited in Claim 1. For example, it is unclear whether the nickel plated steel alloy discussed in the Cook reference could be used in the method of Claim 1. In fact, it appears as though the nickel plating is being used as the marking material in this instance. A similar argument can be made for Claim 9. The '462 Tatah reference and the Addiego et al. reference fail to supplement this deficiency as neither discusses the use of the specific steels recited in Claims 11 and 12, or the marking materials of Claim 9 for use in the method of Claim 1. Accordingly, the Applicants submit that Claims 9, 11 and 12 are allowable over the cited references.

Regarding the anticipation rejection of Claim 9 based on the Hase et al. reference, the Hase et al. reference describes various oxide films, but does not disclose the materials or compounds thereof specified in Claim 9. Accordingly, the Applicants respectfully request the withdrawal of the anticipation rejection of Claim 9.

While Claim 1 has not been rejected as being anticipated or obvious, the Applicants wish to note that the cited references do not recite a method for marking materials comprising both a first process including vaporizing the marking material by irradiating with a first laser beam and depositing a deposit onto a material to be marked, and a second process of at least one of removing or denaturalizing a part of the deposit with a second laser beam, as further

recited in Claim 1 of the present application. Accordingly, the Applicants submit that Claim 1, and dependent Claims 2, 3, 10, 15, and 23 are allowable over the references of record.

Consequently, in view of the foregoing amendments and remarks, no further issues are believed to be outstanding and the present application should be considered in clear condition for formal allowance. Therefore, a quick and favorable action to that effect is respectfully requested.

Respectfully submitted,

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Marked-Up Copy

Serial No.: 09/380,630

Amendment Filed on: October 3, 2002

IN THE SPECIFICATION

At page 23, line 12 through page 24, line 6, please delete the paragraph and substitute therefor:

Fig. 4 shows a structure of embodiment 2 and a marking process thereof. In Fig. 4, the symbol 1a represents a thin film such as a metal film formed on glass plate 1b, the numeral 2 a glass plate used as the material to be marked, 6a and 6b are chips to provide a gap between the marking material and the material to be marked (Fig. 4(a)). In the present embodiment, there is provided a gap of about 50 μm. The marking method comprises the steps of scanning and applying a laser beam LA such as the YAG laser to metal film 1a through glass plate 2 to evaporate metal film 1a, thereby making a film M deposit to a specific area of glass plate 2, as shown in Fig. 4(b); successively separating glass plate 2 from glass plate 1b at a Z stage not shown and then scanning the laser beam LA while controlling irradiation thereof by means of a Q switch in order to apply the laser beam LA to the predetermined part of the film M, thereby forming a predetermined figure as shown in Fig. 4(c). In the present embodiment, a Two-dimensional Data Code of 7 cells × 7 cells is prepared.

At page 24, lines 7-11, please delete the paragraph and substitute therefor:

The present embodiment uses chromium for the metal film, soda glass for glass plate 1b, and fused silica for glass plate 2. The two-dimensional Data Code mark formed on glass plate 2 has a clear contrast and is easily recognizable after marking by using a data code reader.

At page 24, line 12 through page 25, line 18, please delete the paragraph and substitute therefor:

Subsequently, in the process of Fig. 4 (b), the quantity of light of a Krypton arc lamp, which is a laser excitation source, is intentionally varied during marking to form the fluctuated state of the laser power shown in Fig. 3, thus forming a Two-dimensional Data Code. The maximum power fluctuation rate at this time is decided as 50 % of the peak power. The Two-dimensional Data Code thus formed is easily recognizable by means of the data code reader in the same way as the Two-dimensional Data Code formed in the state with no power fluctuation resulting in the clear mark. When the metal film on the glass plate is used as the marking material in this way, since the heat capacity of the metal film is small compared to that of bulk materials, all the metal film is evaporated by the small laser power and then deposited on the glass plate. Therefore, the metal film is not affected by variation of the laser power, thereby being able to provide a code mark of high reading reliability. Further in the present embodiment, although a chromium films of a thicknesses of 0.1 μm, 0.2 μm, 0.3 μm, 0.5 μm, 0.7 μm, 1 μm, 2 μm, 3 μm, 5 μm, or 10 μm is used as the metal film, all succeeded in forming a clear two-dimensional mark. However, in the case of film thickness of 3 μm or more, a part of the chromium film on glass plate 1b, which is not used for forming the code, sometimes strips off at the time of marking, and it is desirable that the film

thickness thereof be 2 μm or less for practical use. Further, it is apparent that a Two-dimensional Data Code being heat-and chemicals-proof can be provide when stainless steel or steel is used as the metal film. Other metal film made of the marking material described in embodiment 1 may also be used.

At page 25, line 19 through page 26, line 14, please delete the paragraph and substitute therefor:

In the present embodiment, although a marking material having a metal film deposited on the glass plate is used, inorganic material such a sapphire, quartz other than glass plate may be used as long as the laser beam transmits through the material. Although the YAG laser is also used in the present embodiment as the laser beam, if it matches the material to be marked, it is allowable to use a carbon gas laser. For example, in the marking operation can be performed with the structure and the process shown in Fig. 4, if a silicon wafer is used as material-to-be-marked [2], organic matter such as paint or ink or metal such as Cr or gold or inorganic matter such as iron oxide, SiO_2, silicon nitride is used as thin film [1a], and a silicon wafer is used as substrate [1] of thin film [1a], paint or ink, Cr or gold, iron oxide or SiO_2 or silicon nitrade can be marked on silicon wafer [2]. In the present embodiment, review of recognition performance is performed with reference to the mark expressed with the Two-dimensional Data Code, however, QR Code, Veri Code, or a two-dimensional bar code, each of which in a minute code, or bar code can be used as the code.

At page 28, line 21 through page 29, line 12, please delete the paragraph and substitute therefor:

In the present embodiment, a Two-dimensional Code as shown in Fig. 6 is made by using titanium as the material according to the same procedure as that of embodiment 1. Results of marking are shown as parameters of the first laser power and the second laser power. In Fig. 6, a code is composed of 20 cells arranged widthwise and 20 cells arranged lengthwise, in total 400 cells. An L pattern is composed of the left side and the bottom side, and the right side and the upper side pattern have white and black marks arranged therein alternately. Both **[**configuration**]** <u>configurations have</u> a pattern **[**wit**]** <u>with</u> which a two-dimensional code reader discriminates the position of the code. 18 horizontal and 18 lengthwise directional cells amounting to 324 cells are surrounded by the above four sides and record data such as a diagram, a numeral, or an English character. In other words, the Two-dimensional Code of the present embodiment can record data of 324 bits.

At page 29, line 13 through page 30, line 9, please delete the paragraph and substitute therefor:

A procedure for manufacturing the **[**Atwo-dimensional**]** <u>Two-dimensional</u> Code comprises the steps of scanning the laser beam in the first process by a 50 μm interval as shown by the arrow mark in Fig. 7. Then, forming each square cell of a white ground by scanning and applying the laser beam to form a pattern of a □ type as shown in Fig. 8 by the second laser power (10 W in the present embodiment) in the second process, thereby entering data in 400 cells in total. By scanning the laser beam while keeping the first laser power constant (in the present embodiment, 30 W), the irradiation energy power is raised to increase the amount of metal evaporated at the place where the laser beam turns, corresponding to the

left and right sides shown in Fig. 7 (an enlarged part of Fig. 7), thereby increasing the amount of metal deposited to the glass plate, resulting in a Two-dimensional Code having a thick film at the turning point. Therefore, two problems are raised. First, in the second process, the film on the glass plate can not be removed sufficiently at the thick portion, consequently producing [speck] specks. Second, since the L pattern formed in the second process requires linking □ patterns together and drawing takes a long time

At page 32, lines 5-16, please delete the paragraph and substitute therefor:

With a first laser power of 20W, since there is scarcely any film deposited to the glass plate, no readable Two-dimensional Code is made. Further, since the Two-dimensional Code made by a first laser power of 30W and a second laser power of 30W has a lot of [speck] specks, it is unreadable by the two-dimensional code reader. Further, with a first laser power of 70W and a second laser power of 15W or less, the film cannot be perfectly removed, so the mark cannot be read by the two-dimensional code reader. From the above results, it is obvious that a readable Two-dimensional Code can be made when the first laser power is higher than the second laser power.

At page 47, line 5 through page 48, line 19, please delete the paragraph and substitute therefor:

In the present embodiment, it was tried to form marking by applying the laser beam to an indium-tin compound oxide film (hereinafter referred to ITO film) coated on a glass plate with a predetermined laser power (in the present embodiment, 0.08W or less) and by scanning the laser beam so as to form a specific character. In a portion of the ITO film irradiated by the laser beam with the power of 0.02 to 0.08 W, scarcely any change can be

detected with the naked eye. However, when the portion of the ITO film irradiated by the laser beam through a band pass filter for transmitting light with wavelength of 700 to 800 nm was checked, it was found that the reflection light is remarkably reduced, and the portions of the ITO film irradiated and not irradiated by the laser beam make a clear contrast which can be easily recognized. That is, the portion irradiated by the laser beam looks black because the light transmits therethrough, and the portion not irradiated by the laser beam looks white because of reflecting the light, thereby producing a mark with a clear contrast. In the present embodiment, characters are recognized due to reflection light, but they can also be recognized in the same way with transmission light. In recognition due to the transmission light, the portion irradiated by the laser beam looks white because the light transmits therethrough, and the portion not irradiated by the laser beam looks black because the light is reflected, thereby producing a mark with a clear contrast. Therefore, if the [reflexibility or the transmittivity] reflexivity or the transmissivity of the film on the glass plate is varied by irradiation of the laser beam, a recognizable mark can be obtained. In the present embodiment, the laser beam is applied to the ITO film on the glass plate for varying the [reflexibility and the transmittivity] reflexivity and the transmissivity, however, if a film made of metal, alloy, a metallic compound or a compound of these matters other than the ITO film is used and the [reflexibility] reflexivity as well as the transmissivity of the film can be varied by irradiation of the laser beam, it is evident that the same effect will be obtained. Further, by applying the present embodiment to the second process of embodiment 1, a mark of a clear contrast was successfully obtained.

IN THE CLAIMS

1. (Three Times Amended) A method for marking materials using a marking material and a material to be marked consisting of a light transparent body or a laser transmittive body, comprising:

a first process of placing a surface of said material to be marked and a surface of said marking material together with a desired gap therebetween, vaporizing said marking material by irradiating through said material to be marked with a first laser beam while scanning with the first laser beam, and depositing a deposit vaporized from said marking material onto a predetermined portion of said material to be marked; and

a second process of at least one of removing or denaturalizing a part of said deposit deposited onto the surface of said material to be marked by irradiating the part of the deposit with a second laser beam while scanning with the second laser beam;

wherein patterns of characters, diagrams or symbols are formed on said material to be marked; and

[wherein the deposit caused to degenerate by irradiation by said second laser beam is changed in color by heating; and]

wherein said desired gap is between $2\mu m$ and $200\mu m$.

9. (Twice Amended) A marking material for use in [either] claim 1 [or 5], wherein the marking material used is a metal, alloy, intermetallic compound, or [a] compound[, alloy or intermetallic] thereof.

10. (Three Times Amended) A method for marking [material of] materials according to claim [9] 1, wherein the deposited marking material is a thin film formed on the surface of the material to be marked [is of] having a thickness of 10 μm or less.

11. (Once Amended) A marking material for use in [either] claim 1 [or 5], wherein the marking material is steel or stainless steel.

12. (Twice Amended) A marking material for use in [either] claim 1 [or 5], wherein the marking material is either a martensite or a ferrite stainless steel, or a carbon steel, or a steel with a carbon content of 0.25% or less.

15. (Twice Amended) A <u>method for</u> marking [material] <u>materials</u> according to claim [9] <u>1</u>, wherein [the pattern] <u>one of the patterns</u> formed is QR Code, Data Code, Veri Code, a two-dimensional code, or a bar code.

23. (Once Amended) A <u>method for</u> marking [material] <u>materials</u> according to claim 10, wherein the thickness is 0.1 to 2.0 μm.

Appendix

An Introduction to Bar Coding

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Mr Tan is the Chairman of Automatic Data Capture Technical Committee

Abstract

The aim of this article is to review the developments of different bar codes, their applications and the future trends, particularly in the field of medicine. It will also cover three basic types of barcodes, namely linear, 2D and composite barcodes. Applications of bar code can be found in retail, logistics, military, healthcare and the electronic sectors.

1. Introduction

Linear Bar Codes are a part of our everyday lives, coming into play at supermarkets, convenience stores, bookstores, libraries, hospitals, post offices etc. Bar Codes did not take off until the 1980s. Now we are starting to see the successor to the linear bar code in the form of 2 Dimension (2D) Symbologies.

The aim of this article is to review the developments of different bar codes, their applications and the future trends, particularly in the medical fields. It will also cover three basic types of bar codes, the linear, the 2D and the composite.

Section 2 relates a brief history of bar codes. This is followed by a description of the Liner Bar Code symbologies in Section 3 and an overview of recent developments in 2D Bar Code symbologies in Section 4. Finally, a brief introduction to Reduced Space symbology is given in Section 5.

2. The History

Bar Coding is an automatic identification (Auto ID) technology that streamlines product identification and data collection.

The first concept of linear bar code was developed about 65 years ago in the mid 1930s. In 1949, Woodland and Berny Silver developed the Bull's Eye symbology and applied for patent in the U.S.A. However, due to limitations in printing technology and Auto ID technology, it took more than 20 years for RAC to develop a solution to operate the Bull's Eyes symbology and scanner in a Kroger store in Cincinnati, Ohio, U.S.A. Thus, 1972 marked the first adoption of the early bar code system in the retail industry.

Revisions and developments from this initial test site led to the development and adoption of the UPC (Universal Product Code) symbol by grocery stores in the United States. The UPC is administered in the U.S.A. by the Uniform Code Council (UCC) and in Canada by the Product Code Council of Canada.

During the 1970s, bar coding became increasingly practical and economical. With the advent of low cost electronics (microprocessors) and lower cost lasers, numerous companies devised their own bar code symbologies and scanning equipment. The stability of the UPC System gave rise to industrial acceptance and the need for standardisation.

Linear Bar Codes (One Dimension Symbologies) generally function as identification (ID) codes for products. Bar codes generally encode information such as product numbers or invoice numbers. The actual information about the product is stored separately in a computer. For example, a bottle of 100% Pure White Sesame Oil 700gm has an EAN-13 digit bar code 888 8007 10031 0. This consists of a Country Code 888 for Singapore, a Company Code 8007 for Chee Seng Oil Factory Pte Ltd, a Product Code 10031 for a bottle of 100% Pure White Sesame Oil 700gm and Check Digit 0. These numbers are used to reference the master record in the computer which stores such data.

1) Bar codes can be printed on paper and a range of other media, making them an extremely cost effective data storage option.
2) A large range of scanners, printers and labellers are readily available from many different manufacturers, so there is a great deal of flexibility for system construction.
3) Several bar codes have accepted worldwide standards, enabling design of systems which can be used internationally.

Bar code systems proliferated quickly because these useful characteristics coincided with the wide acceptance of Point-of-Sales (POS) systems. Accelerated growth in computer usage occurred at the same time and the ability to manage individual products was also a major factor in the sudden and widespread acceptance of bar codes.

3. Popular Linear Bar Code Symbologies

There are many different bar code symbologies. Each symbology has its own rules for character (e.g. letter, number, punctuation) encodation, printing and decoding requirements, error checking, and other features.

The various bar code symbologies differ both in the way they represent data and in the type of data they can encode: some only encode numbers; others encode numbers, letters, and a few punctuation characters; still others offer encodation of the 128-character, and even 256-character, ASCII sets. The latest symbologies include options to encode multiple languages within the same symbol; allow user-defined encodation of special or additional data; and can even allow reconstruction of data if the symbol is damaged.

At the last count, there were about 225 known bar code symbologies but only a handful of these are in current use and fewer still are widely used. Examples are given in Figure 1.

In 1976, when the EAN Bar Code System was developed, it was designed to be fully compatible with the UPC. Today, the global retail industry has fully adopted the EAN.UCC System.

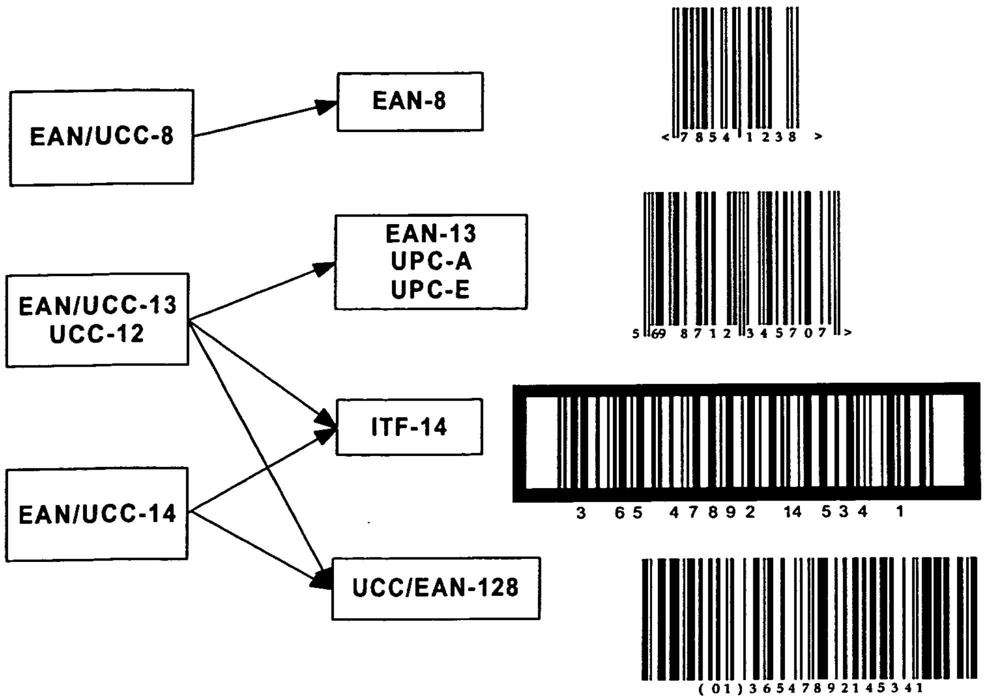


Figure 1. Examples of popular linear bar codes

Popular linear bar code symbologies include :-

- EAN.UPC
- EAN-128
- Interleaved 2 of 5 (ITF-14)
- Code 39

3.1 Linear Bar Code Applications

Linear bar code applications, particularly that of the EAN.UCC system and UCC/EAN 128, continue to grow and expand into new industry sectors. In particular, the healthcare sector requires the unique tracking and tracing functions offered by the UCC/EAN 128.

The EAN.UCC System is adopted by the retail industry worldwide. UCC/EAN 128 has been adopted for the medical device industry in more than 45 countries, including many in Europe, Asia, Australia and South America. Most leading medical device manufacturers in the U.S.A. have also migrated to UCC/EAN 128 to meet global demand for UCC/EAN 128 symbology by hospitals, medical suppliers and National Healthcare Organisations. After an extensive comparison of various healthcare standards for logistics and supply, the Japanese Federation of Medical Devices Associations adopted the EAN.UCC system for medical and paramedical supplies. This decision was made with the full support of the Japanese Ministry of Health and Welfare.

3.2 Singapore Standard

In the early 90s, due to the lack of bar coding standards, industries in Singapore were reluctant to implement Bar Coding System in their operations. In order to address this, the Information Technology Standards Committee (ITSC) appointed the Singapore Article Number Council, the secretariat of the Automatic Data Capture Technical Committee (ADC TC) of ITSC to draft the Singapore Standard for EAN Bar Coding System. It resulted in the publication and released of the following Singapore Standards on 6 March 1993 after these standards were endorsed by the Singapore Standards Council.

Part 1 : EAN – An Unambiguous International Product Identification System
Part 2 : EAN Code 128 and Application Identifier Standard

Since then, EAN Bar Coding System is widely used by retailers, manufacturers and logistic operators in Singapore.

4. Two Dimensional (2D) Bar Code Symbologies

The need to encode more information in a smaller space has driven the development, standardisation and growing use of 2D bar codes. Where traditional linear bar codes act as a license plate to reference information stored in a database, 2D codes can fulfil the same function while taking up significantly less space. In addition, 2D codes can function as the database itself and therefore assure complete portability for 2D labelled items.

The 2D symbology can hold the master data, making it possible to construct systems which do not need to reference a computer for this information. A comparison between Linear Bar codes and Two Dimensional Bar codes is given in Table 1.

Table 1: Comparison between Linear Bar and 2D Codes

Item	Two Dimensional Code	Linear Bar Code
Information Capacity	Approx. 2000 characters	Approx. 20 characters
Information Type	Alphanumeric, Kana, Kanji	Alphanumeric
Storage Density (*)	20 to 40	1
Data Restoration Ability	Yes	No

(*) Storage comparison for an area with identical size, with the bar code taken as a criterion "1"

There are two types of 2D bar codes in current use : stacked codes and matrix codes. Examples of these codes are shown in Figure 2.

4.1 2D Stacked Symbologies

2D stacked symbologies evolved from linear bar code – Code 39 and Code 128 – stacked in horizontal layers to create the multi-row symbologies, Code 49 and Code 16K, respectively.

PDF417 followed in 1990 with added features that increased data capacity, improved data density and strengthened reading reliability by a scanner. These features enabled decoding from scan paths that span multiple adjacent rows while incorporating error detection and correcting techniques. PDF417 encodes the full ASCII character set at a maximum of about 2000 characters to four square inches. Characteristics of 2D Stacked symbologies are listed in Table 2.

Table 2: Characteristics of 2D Stacked Symbologies

Well founded read-only technology
Printable, hence similar to techniques in linear bar codes
Variety of labels and other substrate forms and symbol realisations to suit a variety of applications and user environments
Readable by laser scan technology and image capture systems
Range of symbologies with capacities up to 2000 or more characters
Error detection and correction capabilities in most symbologies
Most symobologies capable of handling international character sets using 'extended channel interpretation' system

4.2 2D Matrix Symbologies

2D matrix symbologies offer higher data densities than stacked codes in most cases, as well as orientation independent scanning. A matrix code is made up of a pattern of cells that can be square, hexagonal or circular in shape. Data is encoded via the relative positions of these light and dark areas and encoding schemes use error detection and correction techniques to improve reading reliability and enable reading of partially damaged symbols. Matrix codes are scaleable and well suited both as small ID marks on products and as conveyor scannable symbols on shipped packages. Characteristics of 2D Matrix symbologies are listed in Table 3.

Table 3: Characteristics of 2D Matrix Symbologies

Well founded read only optical technology
Printable similar techniques to linear bar codes
Variety of symbol forming techniques (printing methods for label based symbols, pierced metal, impressed and composite formed symbols)
Range of symbologies with capacities up to 2000 or more characters
Error detection and correction capabilities essential
Handle international character sets either natively or through extended channel interpretation

,p,q CODE | PDF417 | DATA MATRIX | MAXICODE

VERI CODE | CODABLOCK | AZTEC CODE | CODE16K

Figure 2. Examples of 2D Codes

4.3 The QR Code : 2 Dimensional Symbology

QR Code is an abbreviated name for Quick Response Code. As indicated by its name, QR Code is a 2D symbology developed to enable swift response for ultra high speed reading and ultra high speed processing purposes. It is a matrix type 2D Symbology developed by Denso Corporation, Japan in September 1994. In view of QR Code's unique ability to encode Chinese language character, Kanji, Korean language character, it will have huge market potential for the Asian markets. QR Code is able to detect errors. It is able to perform error correction function (data restoration function). Thus QR Code can be read even when the code is soiled and damped. Distinct features of this code are given below together with its specification and summary presented in Table 4.

Ultra high speed and omni directional reading

A single item of QR Code consisting of 100 characters of data can be read in 32 milliseconds. This amounts to approximately 30 items of code being read in one second, which represents a ten fold increase in reading speed as compared with other 2D symbology

Minimal space required for data encoding

As QR Code uses a method which relies on the existence or non-existence of cells (dots), as opposed to bar codes which use thick or thin lines. Data coding at high levels of density is possible with existing printer and labeller functions. For example, data can be encoded into an area approximately one-tenth the size of bar codes. In other words, 100 times the data volume can be encoded into the same sized area.

Efficient encoding for a wide range of differing data

Encoding is not only possible for English characters but also for Kanji, Kana (Chinese language character) and binary code, or a mixture of each. For example, this enables Kanji and Kana data to be encoded with a 20% or higher efficiency rate over other 2D symbologies. This unique capability will propel QR Code to be a leading 2D code for Asian countries such as China, Korea and Japan.

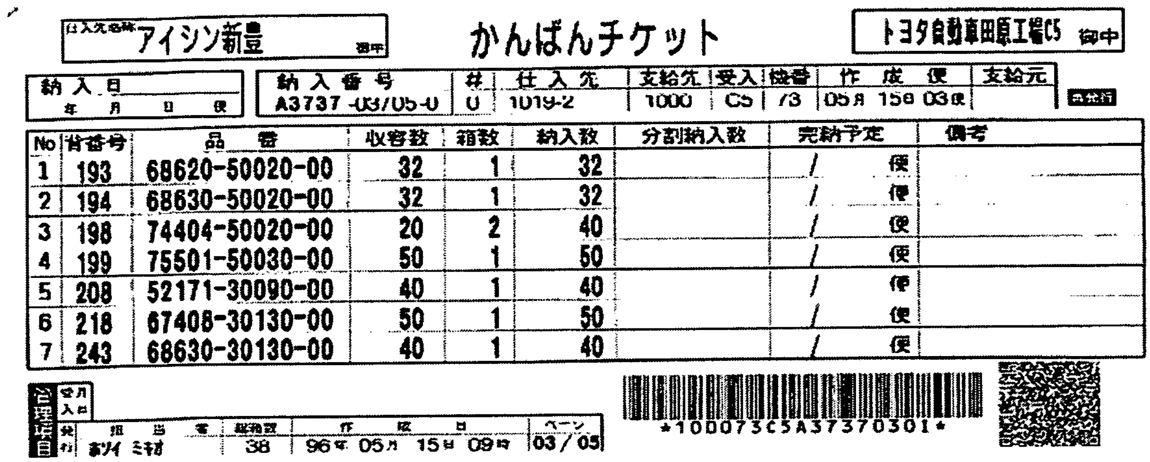
Table 4. QR Code Specifications (Version 1.1)

Code Size	21 x 21 cells, 25 x 25 cells to 177 x 177 cells (size grows by 4 cells per version) Example : If 105 cells (0.25 mm/cell) are used, the size of the space required is : 0.25mm x 105 = 26.25mm square (+ 4 cells for quiet zones)
Type &Amount of Information (Mixed use permitted)	Numeric : 7,366 characters max.
	Alphanumeric symbols :4,464 characters max.
	Binary (8 bits) : 3,069 characters max.
	Kanji : 1,888 characters max.
Error Correction Capability	Data can be restored even if : Level 1 : approx. 7% of the code is smeared or damaged
	Level 2 : approx. 15% of the code is smeared or damaged
	Level 3 : approx. 25% of the code is smeared or damaged
	Level 4 : approx. 30% of the code is smeared or damaged
High Speed, omni-directional, remote reading	Approx. 30 codes (100 char./code) = 32 msec./100 char. 360 degrees (all directions)
Larger amount of data in a smaller space (High density printing)	
High durability against dirt and damage	Data can be restored even if up to 30% of the code area is smeared or damaged
Ability to encode Chinese language character, Kanji	

4.3.1 QR Code Applications

In Japan, large Corporations such as the Toyota Motor Group, the Japan Wiper Company, Yuki Corporation (Mail Order Company) and circuit board manufacturers have adopted QR Code in their manufacturing process, inventory control system and shipment management system combining QR Code in the Kanban system.

Figure 3 and Figure 4 show an example of a shipping/receiving slip system using the QR Code of the Toyota Group.


アイシン新豊　かんばんチケット　トヨタ自動車田原工場C5 御中

納入日	納入番号	#	仕入先	支給先	受入	機番	作成便	支給元
年 月 日 便	A3737-03/05-0	0	1019-2	1000	C5	73	05月 15日 03便	

No	背番号	品番	収容数	箱数	納入数	分割納入数	完納予定	備考
1	193	68620-50020-00	32	1	32		/ 便	
2	194	68630-50020-00	32	1	32		/ 便	
3	198	74404-50020-00	20	2	40		/ 便	
4	199	75501-50030-00	50	1	50		/ 便	
5	208	52171-30090-00	40	1	40		/ 便	
6	218	67408-30130-00	50	1	50		/ 便	
7	243	68630-30130-00	40	1	40		/ 便	

担当者	総箱数	作成日	ページ
ホソイ ミキオ	38	96年 05月 15日 09時	03/05

100073C5A37370301

Figure 3. A Sample of a Kanban Ticket

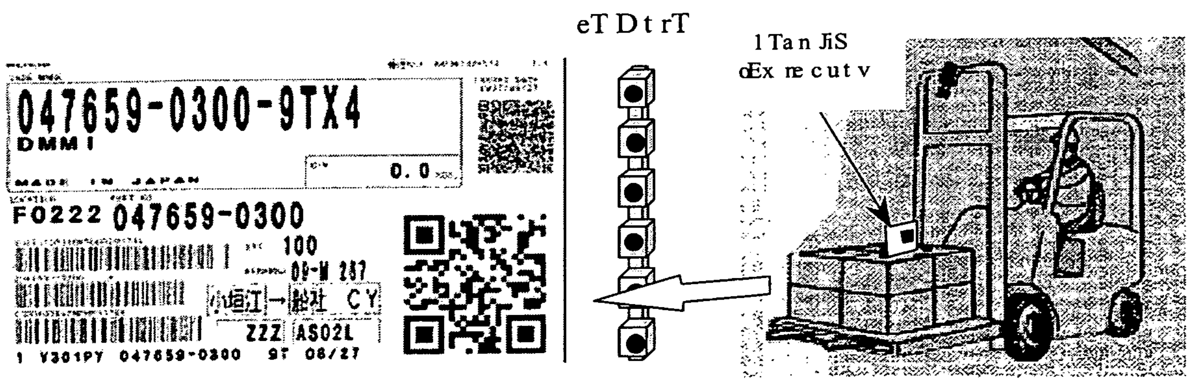


Figure 4. A shipping/receiving slip system

5. EAN.UCC Composite Symbology

For the medical industry and the semi-conductor industry, there is a requirement for a very small sized bar code to identify a particular medicine for patient care management or a particular semi-conductor component.

In order to meet this requirement, EAN International, Brussels and Uniform Code Council, U.S.A. jointly developed the Reduced Space Symbology (RSS). Figure 5 shows examples of such RSS symbology.

The RSS is an EAN.UCC Composite symbol which consists of a linear component (encoding the items' primary identification) associated with an adjacent 2D Composite Component (encoding supplementary data, such as a batch number or expiration date). The Composite symbol always includes a linear component so that the primary identification is readable by all scanning technologies, and so that 2D images can use the linear component as a finder pattern for the adjacent 2D Composite Component. The Composite symbol always includes a multi-row 2D Composite Component, for compatibility with linear and area CCD scanners, and with linear and rastering laser scanners.

RSS 14

RSS 14 Truncated

RSS 14 Stacked

RSS 14 Stacked Omni-directional

RSS 14 Limited

RSS 14 Expanded

RSS Expanded Stacked

Figure 5. Examples of RSS

The RSS family consists of the following versions:-

- RSS 14
- RSS 14 Truncated
- RSS 14 Stacked
- RSS 14 Stacked Omni-directional
- RSS Limited
- RSS Expanded
- RSS Expanded Stacked

The RSS Limited is designed for small items that will not need to be read by omni-directional retail scanners. Its application is for small non-retail items such as medical devices and electronic parts.

6. Conclusion

The purpose of this paper is to introduce the range of popular linear bar coding systems. For the 21st century, the requirements of the industry is to have a bar coding system which can provide traceability functions. The EAN-128 System is the current bar coding system which can fulfil this requirement. We therefore predict that EAN-128 will emerge as the bar coding system for the 21st century.

Bar codes will continue to play a big part in our daily lives especially in the retail industry. The 2D code, such as PDF417 and QR Code will find important applications in manufacturing, medical records management, military logistics management and certification of valuable items.